Common Cause Failure Modeling

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Objective

Provide a method to link the magnitude of Common Cause Failure (CCF) risk to system qualities and to communicate the qualities that affect CCF for industries that do not have CCF data

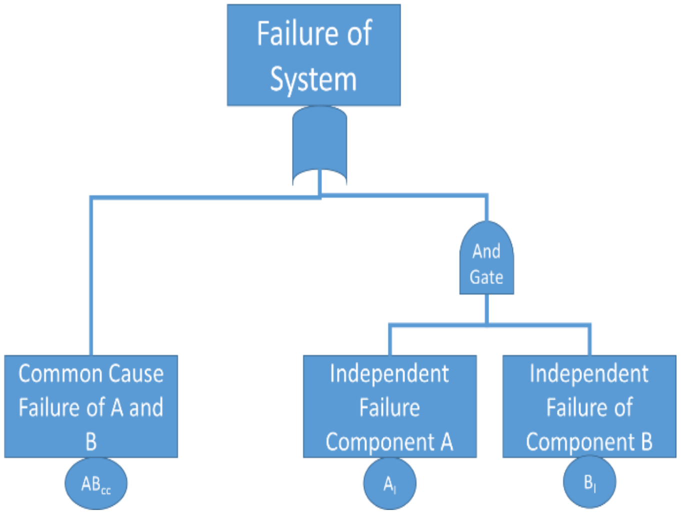
- Explain a basic CCF calculation
- Detail the method
- Apply this method to two example systems
- Detail impacts to the example system and provide general guidance for all systems

Definition of common cause

- *A CCF event is defined as the failure (or unavailable state) of more than one component due to a shared cause during the system mission. Viewed in this fashion, CCFs are inseparable from the class of dependent failures and the distinction is mainly based on the level of treatment and choice of modeling approach in reliability analysis.*

The Beta Method

- $\lambda_T = \lambda_{cc} + \lambda_I$
- $\beta = \frac{\lambda_{cc}}{\lambda_T}$
- $\lambda_{cc} = \beta\lambda_T$
- $\lambda_I = (1 - \beta)\lambda_T$



Purpose of method

- This method serves two purposes:
  - 1) allows an analyst to better model CCF with factors specific to a system that does not have CCF data, and;
  - 2) better communicate CCF coupling mechanisms to system designers, operators and maintainers.

Primary Factors that contribute to CCF

1. Separation/segregation
2. Diversity/ redundancy
3. Complexity/maturity of design/experience
4. Use of assessments/ analysis and feedback data
5. Procedures/ human interface (e.g. maintenance/testing)
6. Competence/ training/ safety culture
7. Environmental control (e.g., temperature, humidity, personnel access)
8. Environmental testing

Methodolgy

- $CCS = 1 \cdot \mathrm{N}_{low} + 5 \cdot \mathrm{N}_{medium} + 10 \cdot \mathrm{N}_{high}$
- $CCF\ Beta = \frac{CCS}{T} \times MCCV$

Area	Low	Medium	High
Separation/segregation	x		
Diversity/ Redundancy	x		
Complexity/maturity/experience	x		
Analysis and feedback data	x		
Procedures/human interface	x		
Competence/training/culture	x		
Environmental control	x		
Environmental testing	x		
sum of x's	8	0	0
Scoring	1	5	10
x * scoring	8	0	0
			CCS
	Total of x * scoring		8

$$CCF\ Beta = \frac{8}{80} \times .30 = \ 3\%,$$

MCCV= maximum common cause value

CCS= common cause score

Example #1: Strong Safety Culture

- Government Oversight
- Heavy effect from public opinion
- Low probability with high catastrophic risk
- Heavy maintenance requirement
- Complex system

- Assume MCCV =20%

Example #1 results

Area	Low	Medium	High
Separation/segregation	x		
Diversity/ Redundancy		x	
Complexity/maturity/experience		x	
Analysis and feedback data	x		
Procedures/human interface	x		
Competence/training/culture	x		
Environmental control		x	
Environmental testing	x		
sum of x's	5	3	0
Scoring	1	5	10
sum of x * scoring	5	15	0
			CCS
	Total of x * scoring		20

$$CCF\ Beta = \frac{20}{80} \times .20 = \ 5\%,$$

Example #2: Poor Safety Culture

- Limited government oversight
- Poor safety record
- Operations very hazardous
- Working environmental conditions are harsh

- Assume MCCV =30%

Example #2 results

Area	Low	Medium	High
Separation/segregation			x
Diversity/ Redundancy		x	
Complexity/maturity/experience			x
Analysis and feedback data			x
Procedures/human interface			x
Competence/training/culture		x	
Environmental control		x	
Environmental testing		x	
sum of x's	0	4	4
Scoring	1	5	10
x * scoring	0	20	40
			CCS
	Total of x * scoring		60

$$CCF\ Beta = \frac{60}{80} \times .30 = \ 23\%,$$

Summary and Conclusions

- Systems require ever higher levels of reliability and in many cases this is achieved by increased redundancy.
  - Without care, increasing redundancy may lead to increased CCFs thereby reducing reliability benefit .
  - Using generic data may grossly understate CCF risk and also significantly overstate system reliability.
- We reviewed the β factor CCF model and showed how it affects overall system reliability.
- Again, this method serves two purposes:
  - 1) allows an analyst to better model CCF with factors specific to a system that does not have CCF data, and;
  - 2) better communicate CCF coupling mechanisms to system designers, operators and maintainers.
- Educating industries about CCF coupling mechanisms will result in more robust and reliable system operations and designs.

Questions?

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